REFEREED PAPER

REVIEW OF FORECASTS OF SEASONAL AVERAGE CANE QUALITY FOR SOUTH AFRICAN SUGAR MILLS

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Abstract

The South African (SA) sugar industry uses Recoverable Value (RV) as a measure of cane quality for cane payment purposes. The RV content of cane stalks (RV%cane) is determined primarily by its sucrose content, fibre content and non-sucrose content. Forecasts of seasonal average RV%cane for each mill are needed to determine monthly payments to growers. These forecasts need to be accurate to minimise payment corrections during and at the end of the milling season. Monthly forecasts are therefore issued from April to the last month of the milling season by mill group boards (MGB) and by the Seasonal RV%cane Forecasting Committee (RVFC) of the South African Sugar Association (SASA). Forecasts are derived from historical and current to-date cane crush and quality data, current and expected growing conditions, prevalence of pests and diseases, conditions that effect harvesting and transport operations, mill performance and expected length of the milling season.

The forecast errors (defined as the difference between the forecast value and the actual value achieved at the end of the season) of MGB and RVFC RV%cane forecasts from 2004 to 2011 were compared with those of two methods based on the to-date RV%cane anomaly.

In the majority of cases, RVFC forecasts were more accurate than MGB forecasts up to about August. A method based on the to-date RV%cane anomaly that also accounts for expected agro-climatic conditions performed better than both these methods in 11 out of 14 cases, from May (when delivery data becomes available) to about August and could be used to improve the accuracy of RV%cane forecasts for the SA sugar industry. It is recommended that the RVFC of SASA incorporate the key elements of the TDRV methods into its forecasting procedures.

Keywords: Recoverable Value, forecast error, cane payment, climate, milling season

Introduction

The South African (SA) sugar industry uses Recoverable Value (RV) as a measure of cane quality for cane payment purposes. The RV content of cane stalks (RV%cane) is determined primarily by its sucrose content, fibre content and non-sucrose content. Sucrose content, and hence RV%cane, typically increases through the milling season, reaches a peak and then declines towards the end of the season, due mainly to climatic factors (rainfall and temperature). While growers would prefer to deliver their cane during the high RV%cane period of the season to maximise payment, millers need a steady (rateable) delivery of cane throughout the entire season to optimise mill operations. The SA sugar industry cane payment system is designed to overcome this problem and to minimise the disparities associated with non-rateable deliveries. Growers are paid for cane delivered based on 'relative RV%cane', which is defined as the sum of the difference between the RV%cane of cane delivered in a given week and mill average RV%cane for the same week, and the mill average RV%cane for the season. This is calculated according to Equation 1:

$$\text{Relative RV\%cane} = (\text{RV\%cane}_{g,w} - \text{RV\%cane}_{w}) + 1/n \sum \text{RV\%cane} \qquad \text{Eq. 1}$$

where subscripts g, w and n refers to grower, week and total number of weeks in the season respectively. The Sugar Industry Agreement of 2000 prescribes that seasonal average RV%cane for a given mill be forecast on a monthly basis by the Mill Group Board (MGB) and that these forecasts be used in payment calculations. The agreement also specifies that a committee of the SA Sugar Association (SASA) makes independent forecasts to assist MGBs in their task. When the actual average RV%cane for a given season is established at the end of the season, a final payment adjustment is made to account for deviations of forecasts form the actual value. It is obviously desirable for this adjustment and forecast discrepancies to be as small as possible. For example, a forecast discrepancy of 0.5 units of RV%cane for a mill crushing 1.0 million tons of cane will require an adjustment of R15 million, assuming a RV price of R3000/ton. This amount will have to paid to the growers if the discrepancy was negative, while it needs to be reclaimed from growers if it was positive.

Monthly forecasts are therefore issued from April to the last month of the milling season by MGBs and by the Seasonal RV%Cane Forecasting Committee (RVFC) of the South African Sugar Association.

This paper (i) describes briefly the methodology of forecasting seasonal average RV%cane, (ii) reviews the accuracy of MGB and RVFC forecasts from 2004 to 2011, and (iii) investigates whether more objective methods could improve forecast accuracy.

Method

MGBs and the RVFC make monthly forecasts of seasonal average RV%cane using historical and current to-date cane crush and quality data, current and expected growing conditions, prevalence of pests and diseases, conditions that effect harvesting and transport operations, mill performance and expected length of milling season. Although these methods make use of objective information, they are subjective to some extent and rely on consensus.

Since 2002, the RVFC have used a decision support system in the form of an Excel spreadsheet model, to assist with the forecast procedure. For each mill in the industry, cane quality data for the past five years are used to generate smoothed long-term average seasonal profiles for sucrose%cane, non-sucrose%cane and fibre%cane. The long-term average profiles are obtained by fitting trigonometric functions to the weekly data (Hoekstra, 1974), and are used as a basis for predicting the cane quality in the current season. The expected profile for each quality parameter for the remainder of the season can be adjusted up or down from the long-term average by specifying a desired offset. After fitted equations have been obtained for each quality parameter, the expected seasonal RV%cane is calculated.

Figure 1 shows some example output from the spreadsheet model. In this example, actual data for the 2011 season was available up to week 16, and the first portion of the red line therefore reflects real data. From week 17 onwards, the red line represents the smoothed long-term average curve, but with a negative offset that adjusts the curve downwards to take into account the expectation of low cane quality for the 2011 season. From this expected trend, the seasonal average RV%cane value can be calculated.

Apart from MGB and RVFC forecasts, 'forecasts' (forecasts made in hindsight) from two additional methods were also evaluated. The first of these methods (named the TDRV1 method) was based purely on the difference between the to-date RV%cane and the long-term mean to-date RV%cane (to-date RV%cane anomaly for a given mill). The second method (named the TDRV2 method) also used the to-date RV%cane anomaly approach, but in addition took into account the effect of recent and likely future agro-climatic conditions. It should be noted that for this analysis, perfect knowledge of future climate was assumed. The effect of the agro-climatic factor was relatively large early in the milling season and declined as the season progressed, while the to-date RV%cane anomaly effect was relatively small in the beginning of the season and increased as the season progressed. The calculation procedure for the TDRV methods is given in the Appendix.

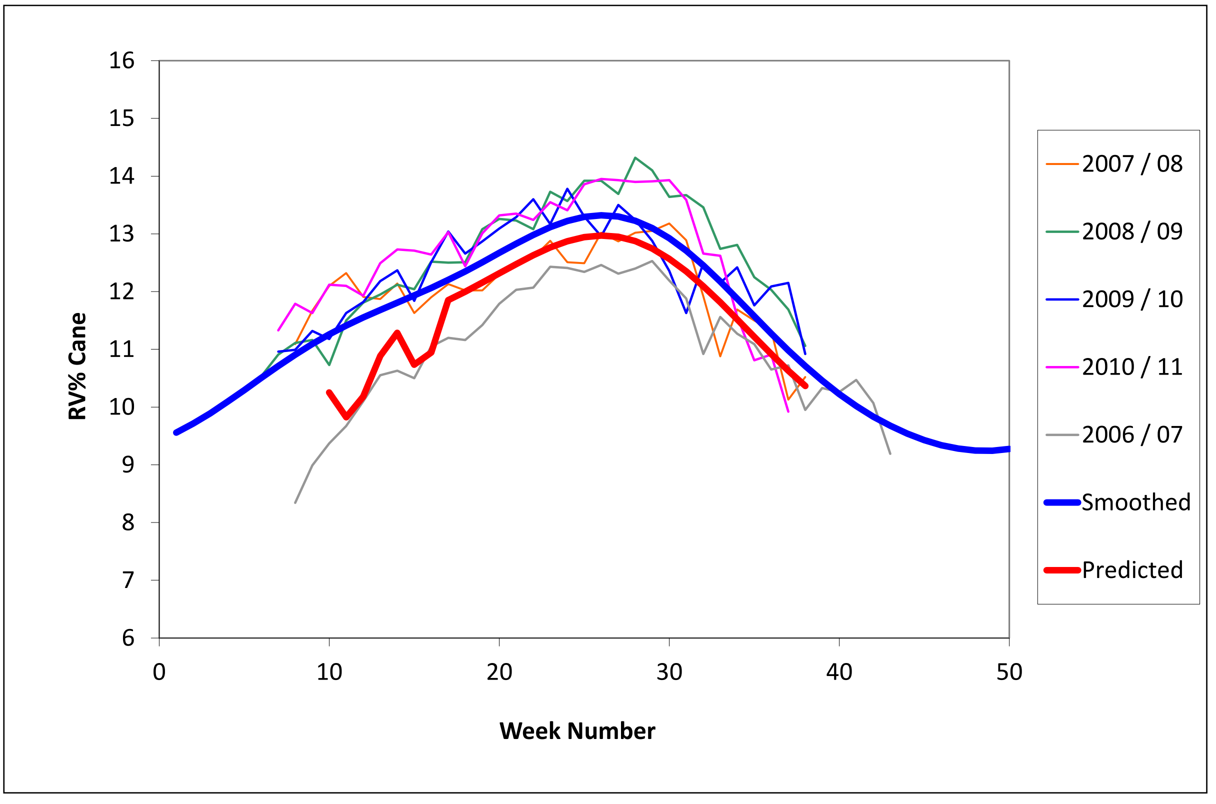


Figure 1. Example output from the RVFC decision support system for RV%cane forecasts (see text for explanation). The historical RV%cane seasonal profiles for the five milling seasons from 2006 through 2010 are shown, as well as the smoothed long-term average RV%cane (thick blue line). The thick red line in the figure represents the predicted RV%cane profile for the remainder of the season.

Results

The forecast error for the different methods is shown for selected mills in Figures 2 to 6.

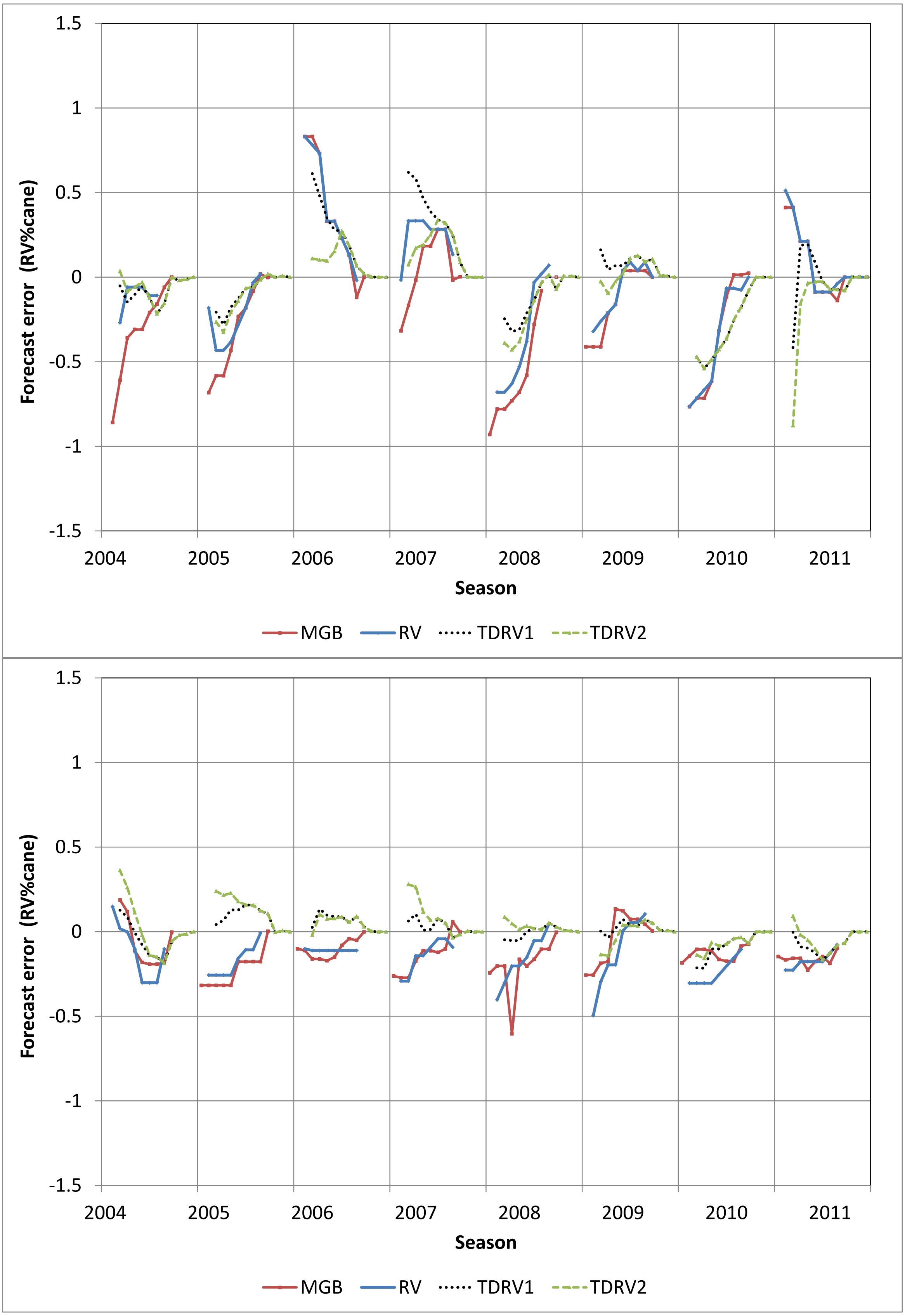
Results in Figures 2 to 4 show that irrigated mills generally had lower forecast errors than rainfed mills, as can be expected due to the lower inter-seasonal variability in cane quality. Early-season (March to June) MGB and RVFC forecasts strongly overestimated (by more than 0.5 units) the relatively low RV%cane achieved for most mills in 2006 (Darnall, Maidstone, Felixton and Umfolozi are exceptions) and 2011 (Felixton and Umfolozi are exceptions) (Figures 2 to 4). These high forecasts were quickly reduced in subsequent months, minimising the potential impact on incorrect payments. The TDRV methods performed better in these cases by taking into account climatic conditions and the quality of early cane deliveries.

In the majority of seasons, early-season MGB and RVFC forecasts underestimated (by more than 0.5 units) actual RV%cane, suggesting that there is a preference for conservative (low) forecasts to minimise the risk of later having to reclaim over-payments made to growers earlier in the season (Figures 2 to 4).

The long term mean error of early-season MGB and RVFC forecasts (Figure 5) varied from about 0.6 units RV%cane for the Maidstone and Eston mills, to about 0.2 units for the Pongola and Komati mills. For all mills the error declined rapidly as the season progressed, dropping to below 0.2 units after August.

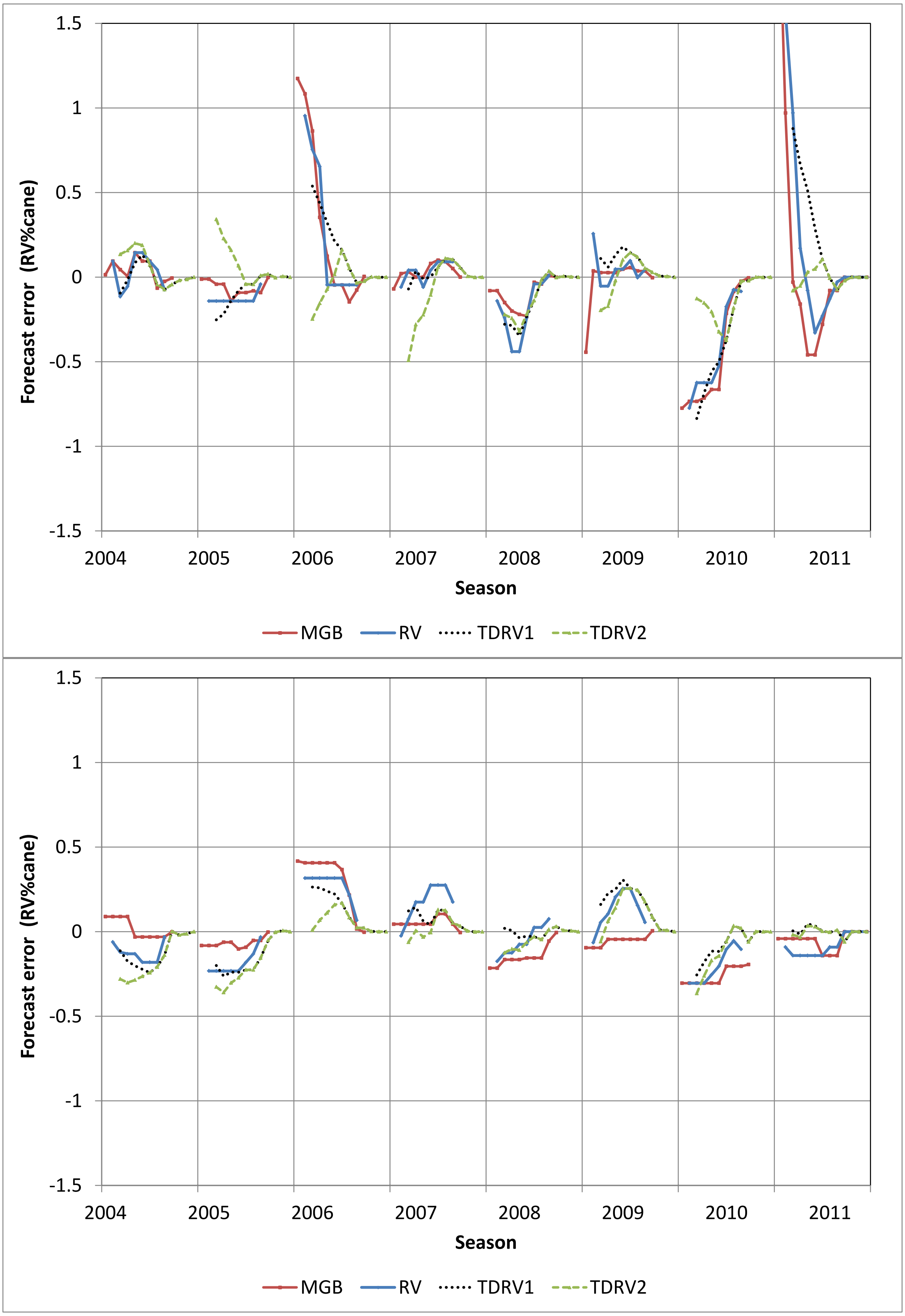
The results in Figure 6 show that early season MGB forecasts for some mills have large (more than 0.3 units) negative bias (Felixton, Amatikulu, Darnall and Maidstone). The bias of RVFC forecasts were mostly smaller than MGB forecasts, with the exception of Umzimkulu. The TDRV methods expectedly had relatively small bias due to their objective nature.

The performance of the different forecast methods is summarised in Table 1. Results show that on average the RVFC method performed better than the MGB method. It had a higher performance ranking than the MGB method in six cases (and worse in two cases), while it had a significant negative bias (exceeding 0.1 RV%cane unit) in four fewer cases than the MGB forecasts (six compared to 10). Both methods had a mean positive bias in two cases (Sezela and Umfolozi). The better accuracy of RVFC forecasts compared to MGB forecasts is ascribed to the use of the forecasting decision support system as well as the independence of the committee.



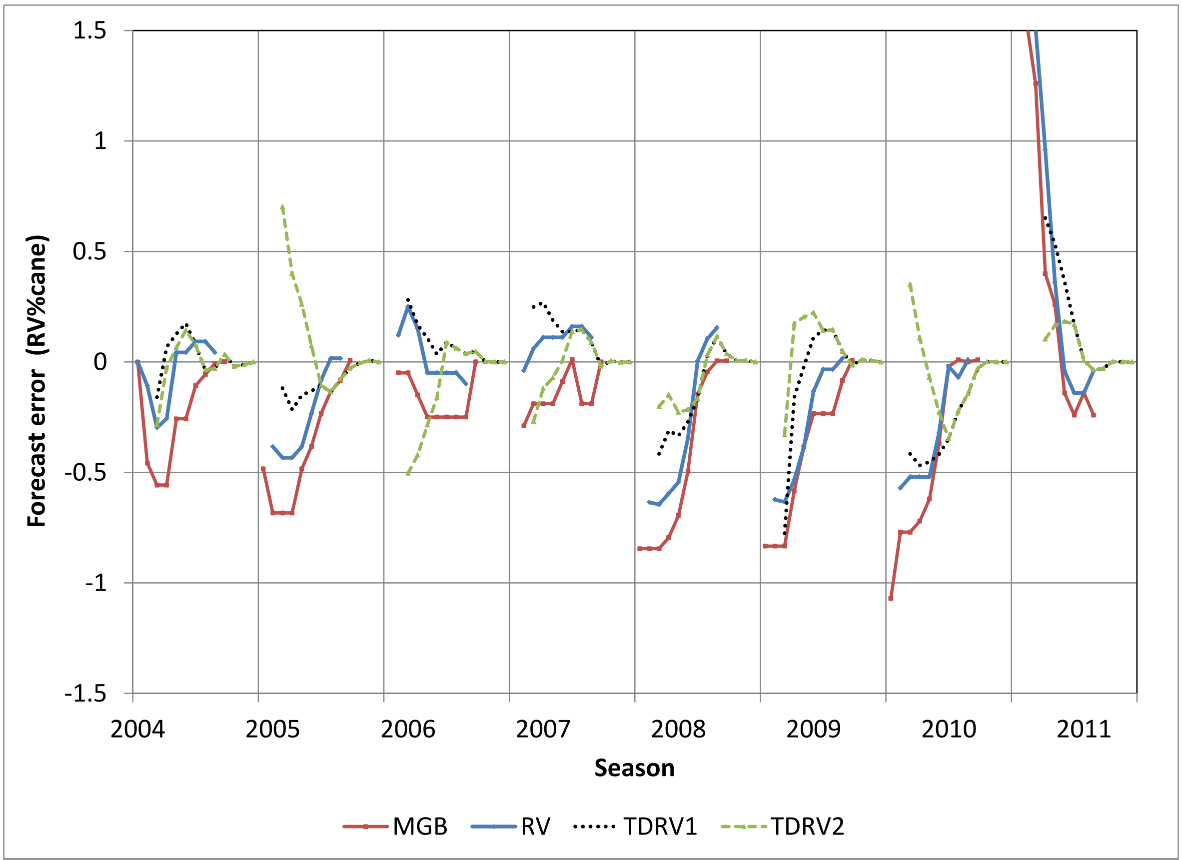
MGB = Mill Group Board   RV = Recoverable Value   TDRV = To-date RV%cane

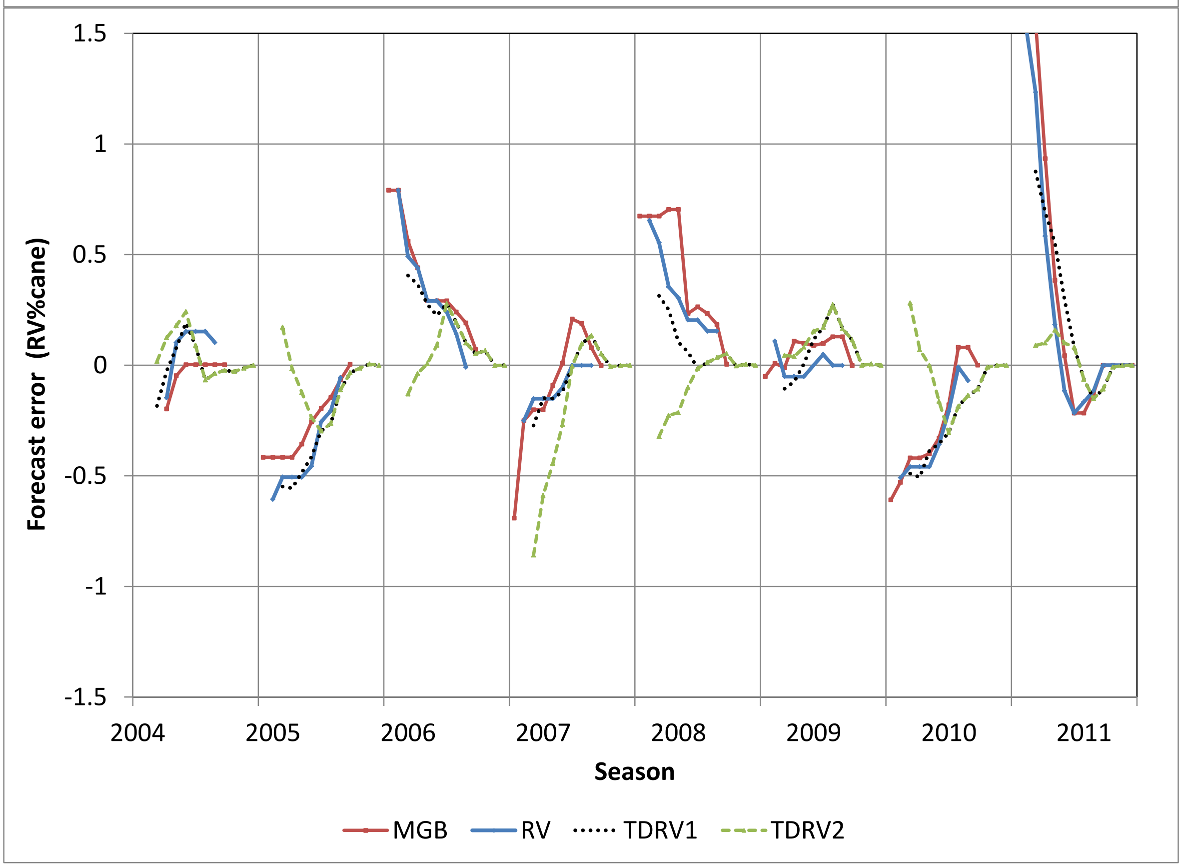
Figure 2. Forecast error of different RV%cane forecast methods for the Amatikulu (top) and Komati (bottom) mills.



MGB = Mill Group Board RV = Recoverable Value TDRV = To-date RV%cane

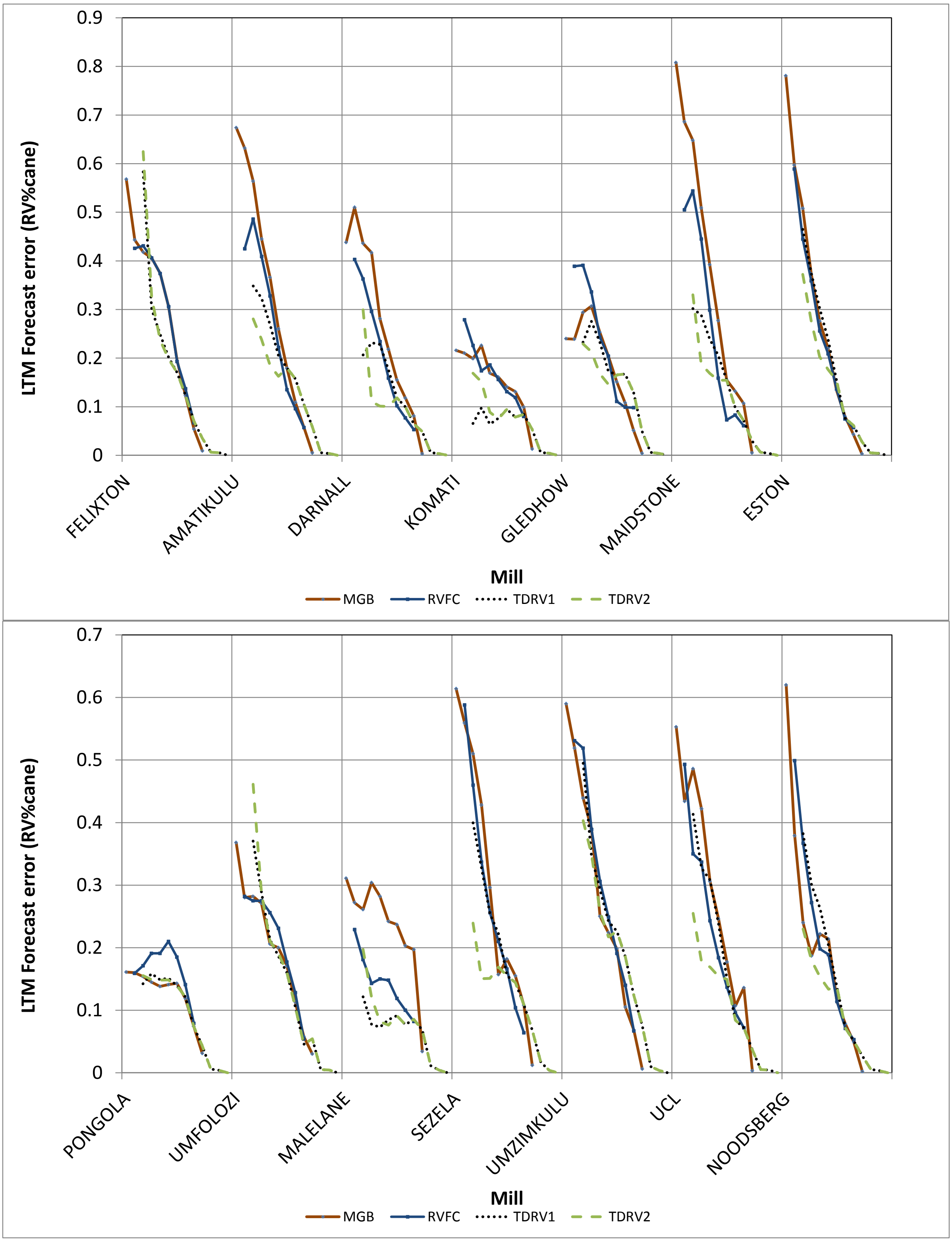
Figure 3. Forecast error of different RV%cane forecast methods for the Noodsberg (top) and Pongola (bottom) mills.





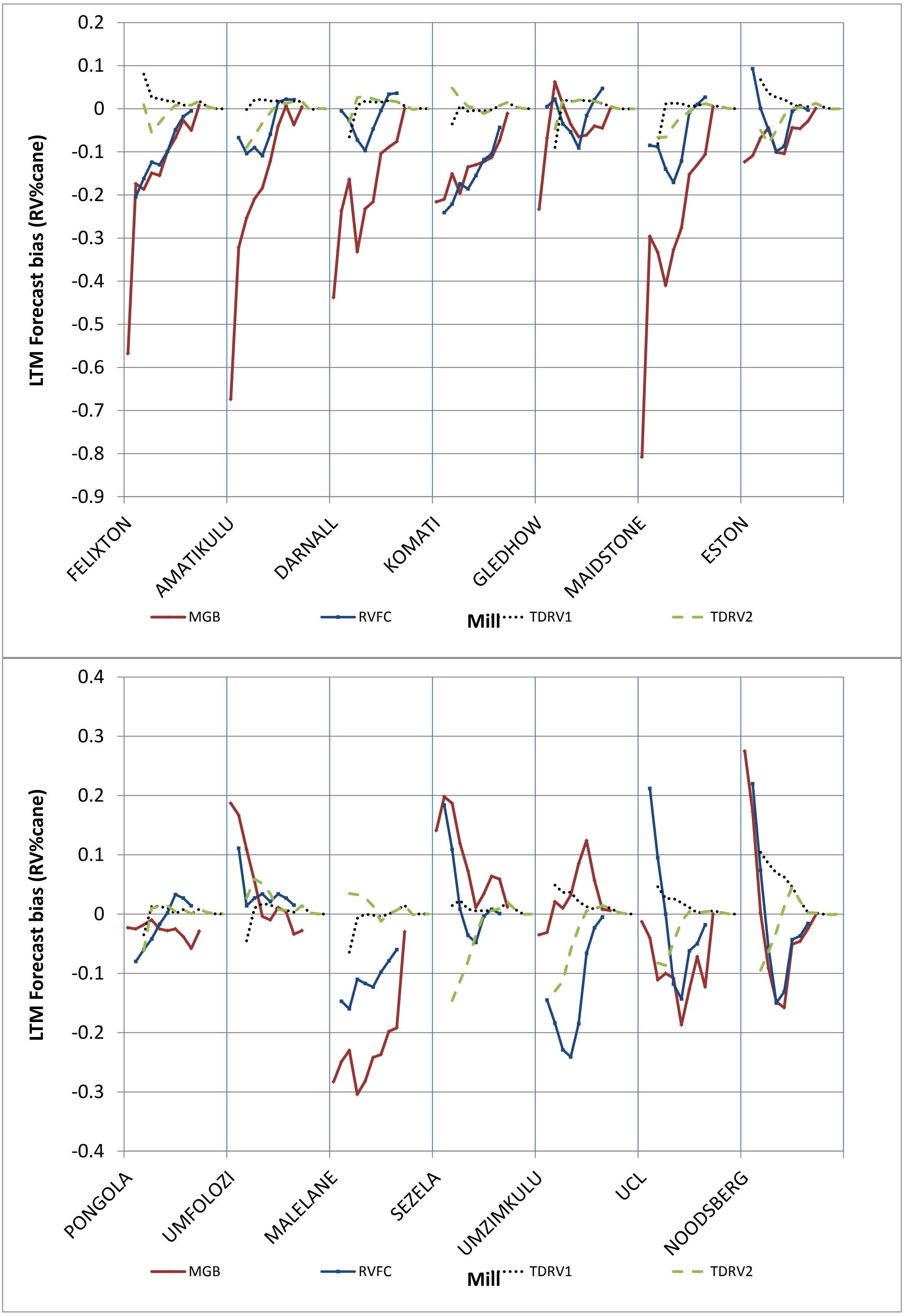
MGB = Mill Group Board RV = Recoverable Value TDRV = To-date RV%cane

Figure 4. Forecast error of different RV%cane forecast methods for the Maidstone (top) and Sezela (bottom) mills.



MGB = Mill Group Board RVFC = Recoverable Value%cane Forecasting Committee
TDRV = To-date RV%cane

Figure 5. Long term mean forecast error for the different methods for each mill.



MGB = Mill Group Board RVFC = Recoverable Value%cane Forecasting Committee
TDRV = To-date RV%cane

Figure 6. Long term mean forecast bias for the different methods for each mill.

Table 1. Performance of different RV%cane forecasting methods for different mills in terms of their performance ranking, the period of the season during which performance was superior and the type (positive or negative) and timing of the bias of the Mill Group Board (MGB) and RV%cane Forecasting Committee (RVFC) forecasts.

Mill	Performance ranking	Period of superior performance	MGB bias	RVFC bias
AMATIKULU	TDRV1 > TDRV2 > RVFC > MGB	May to August	Neg to August	None
DARNALL	TDRV2 > TDRV1 ≈ RVFC > MGB	March to August	Neg to September	None
ESTON	TDRV2 > TDRV1 ≈ MGB ≈ RVFC	March to August	Neg to April	None
FELIXTON	TDRV2 ≈ TDRV1 > MGB ≈ RVFC	June to September	Neg to July	Neg to July
GLEDHOW	TDRV2 > TDRV1 > MGB ≈ RVFC	May to August	Neg in March	None
KOMATI	TDRV1 > TDRV2 > MGB ≈ RVFC	May to October	Neg to October	Neg to October
MAIDSTONE	TDRV2 > TDRV1 > RVFC TDRV2 ≈ TDRV1 ≈ RVFC > MGB	May to July May to August	Neg to November	Neg from June to August
MALELANE	TDRV1 > TDRV2 > RVFC > MGB	May to October	Neg to November	Neg to August
NOODSBERG	MGB ≈ TDRV2 > RVFC ≈ TDRV1	March to June	Pos to April, Neg in August	Pos to May, Neg in August
PONGOLA	TDRV1 ≈ TDRV2 ≈ MGB > RVFC	March to October	None	None
SEZELA	TDRV2 > TDRV1 ≈ RVFC ≈ MGB	May to July	Pos to June	Pos to May
UCL	TDRV1 ≈ RVFC ≈ MGB > TDRV2	March to August	Neg in July,August	Neg in July, August
UMFOLOZI	RVFC ≈ MGB > TDRV1 ≈ TDRV2	March to June	Pos to May	Pos in April
UMZIMKULU	Similar		Pos in September	Neg to August

TDRV = To-date Recoverable Value%cane

The TDRV methods performed better than RVFC and MGB methods for 11 out of 14 mills, for the period May to about August and show little or no bias. It seems that the objective information used in the TDRV methods could contribute significantly to improve forecast accuracy during this period. TDRV2 outperformed TDRV1 in seven cases while the TDRV1 outperformed the TDRV2 method in three cases. This suggests that the additional use of 'expected' agro-climatic conditions improved forecasts based on to-date RV%cane anomaly data in the majority of cases. It should be noted that in this study, actual weather data was used instead of expected weather data, as would be the case operationally. The performance of the TDRV2 method needs to be re-tested in an operational mode.

Conclusions

In the majority of cases, RVFC forecasts of seasonal average RV%cane were more accurate than MGB forecasts up to about August. A method based on the to-date RV%cane anomaly (difference between current and long-term mean) and that also accounted for expected agro-climatic conditions, performed better than both these methods from May (when delivery data becomes available) to about August, in 11 out of 14 cases. It could be used to improve the accuracy of RV%cane forecasts for the SA sugar industry and hence minimise errors and adjustments in cane payments to growers during the course of the milling season. It is recommended that the RVFC of SASA incorporate the key elements of the TDRV methods into its forecasting procedure.

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APPENDIX

The TDRV forecasts were calculated for month ***m*** in season ***s*** as follows:

TDRV1 $RVFCAST_{m,s} = 1/n \sum (RVFIN_s) + TDRVANO_{m,s}$ Eq. 4

$TDRVANO_{m,s} = RV\%CANE_{m,s} - 1/n \sum RV\%CANE_m$ Eq. 5

TDRV2 $RVFCAST_{m,s} = 1/n \sum (RVFIN_s) + RVIOFFSET_{m,s}\, f_m + TDRVANO_{m,s} \cdot g_m$ Eq. 6

where $g_m = m/8$ and $g_m \leq 1$ Eq. 7
and $f_m = (6-m)/5$ and $f_m \geq 0$ Eq. 8

where $RVFCAST_{m,s}$ is the RV%cane forecast issued in month *m* and season *s*, $RVFIN_s$ is the final RV%cane realised for a given season, $TDRVANO_{m,s}$ is to-date RV%cane anomaly for a given month and season, n is the number of seasons, $RVIOFFSET_{m,s}$ is an offset for a given month and season to capture the effect of recent and expected future agro-climatic conditions (derived from the Canesim crop forecasting system of Bezuidenhout and Singels, 2007), and parameters f_m and g_m are weighting factors to phase out the agro-climate effect and phase in the influence of TDRVANO, respectively (see Figure 7). Variable m represents month and was assigned a value of 0 for March, incremented with each subsequent month to a value of 12 for the next March within the given milling season.

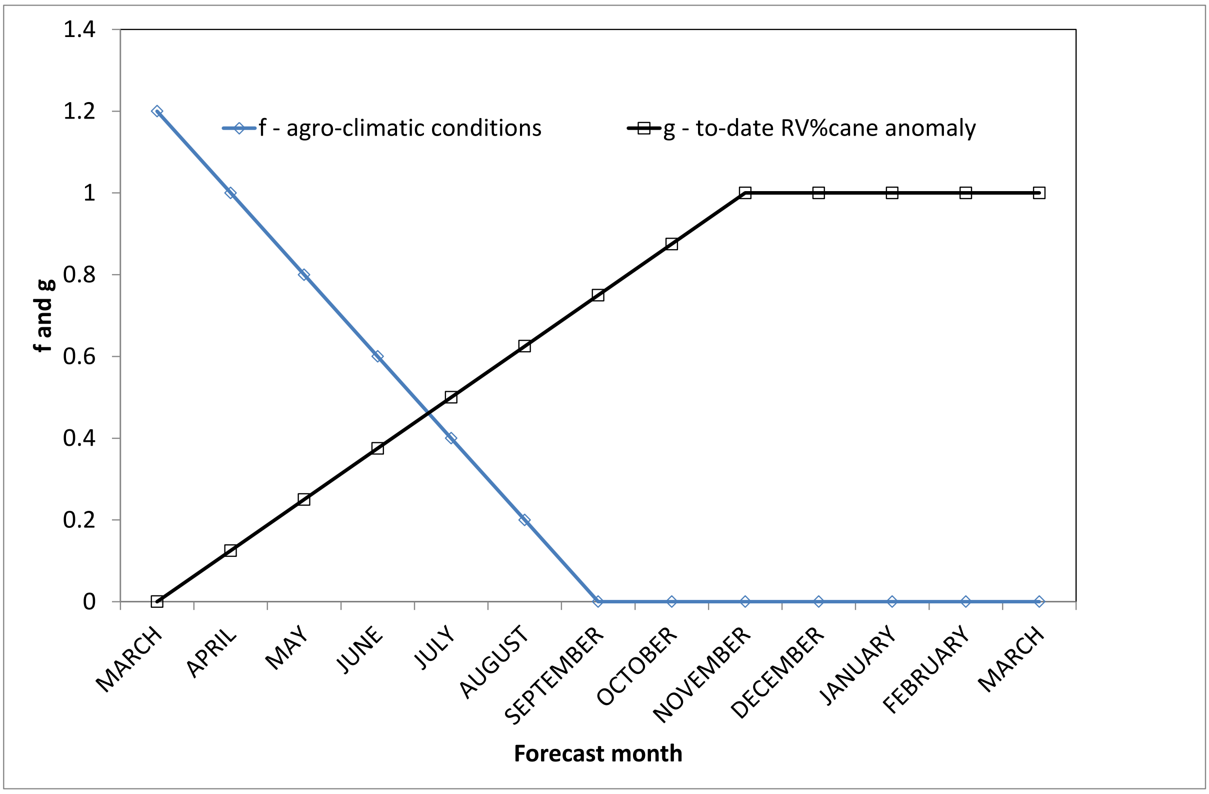

Figure 7. Weighting factors f and g for each month (see Equations 7 and 8) for the effect of expected agro-climatic conditions and the effect of to-date RV%cane anomaly on RV%cane forecasts.

RVIOFFSET is calculated according to Eq. 9:

$$RVIOFFSET_{m,s} = RVIPERC_s\ [\ (RVFINx\text{-}RVFINn) - (RVFINx\text{-}RVFINn)/2\ ] \qquad \text{Eq. 9}$$

$RVIPERC_s$ is the percentile value (expressed as a fraction) of the predicted RV%cane index (RVI) for that season, and RVFINx and RVFINn are the long-term maximum and minimum values of actual RV%cane for a given mill. $RVIPERC_s$ was calculated by comparing the predicted RVI for the current season to RVI data for 1980 to 2011, for a given mill.

RVI represents the effect of agro-climatic conditions (temperature and soil water conditions represented by variables FT and FW in Equations 11 and 12) on sucrose accumulation (and hence RV accumulation) and is calculated using Equations 10 to 12 (adapted from Singels and Bezuidenhout, 2002).

$$RVI_d = FW.FT \qquad \text{Eq. 10}$$
$$FT = 1/(1 + e^{[0.32\ (T-25)]}) \qquad \text{Eq. 11}$$
$$FW = (1 - ASWC/(0.55\ ASWC_{CAP}))^{0.5} \text{ and } FW >= 0 \qquad \text{Eq. 12}$$

where T is daily mean temperature, ASWC is daily available soil water content and $ASWC_{CAP}$ is available soil water capacity. The RVI for a crop is taken as the average daily RVI (RVI_d) for the last 30 days before harvest. The average RVI for a mill was calculated using the Canesim crop forecasting system (see Bezuidenhout and Singels, 2007).